with the respects of the author

DR. JOHN GORRIE'S

APPARATUS

FOR THE

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Artificial Production of Ice,

IN TROPICAL CLIMATES.

PATENTED, 1851.

HENRY E. ROEDER, Engineer,
AGENT, NEW-YORK.

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The Artificial Production of Ice.

A marked property of matter is that a diminution of its volume is attended with an evolution. and an enlargement with an absorption of heat. The nature of the principle by which these effects are made known, we are not acquainted with, and shall not, probably, be ever able to discover. Careful experiments, however, have pointed out to us—both in a positive and negative—a redundant or deficient state—the relation it bears to matter, and thus afford a datum by which we may calculate its force, and be enabled to apply it as readily to the production of refrigerative, as it has heretofore been to caloric purposes.

Aerial bodies manifest this property of an increased or diminished capacity for heat, under an expansion or diminution of their volume, in a high degree. In this as in all the relations between matter and the forces which animate it, the agencies by which they act upon each other, are so minute or imperceptible, that their effects are well calculated to perplex and embarrass the experimental philosopher. In attempts to determine the solution of the simple question, "What is the quantity of heat disengaged and absorbed by the condensation and expansion of common air?" results have been encountered that have set at defiance the deduction of a consistent theory. Dalton, Leslie, Gay—Lussac, and many other names distinguished in the ranks of physical science, are associated with experimental investigations of the connection which exists between air and heat; but their conclusions from them have been so discordant, that it would be irrational to take any one as a datum on which to found a practical object. All, however, show the probability that the relation between heat, and the quantity of mechanical force required to set it free from air, justifies its consideration as a source of artificial

heat; while the quantity of heat absorbed, and the quantity of mechanical power exerted in the expansion of air, render it certain that it can be used advantageously as an agent for the production of artificial cold. Its value for the latter object I have fully determined, by experiments different in plan, and free from the errors of previous experimenters, but agreeing with a mean of their various results, and according with the deductions of a sound theory.

In all ages ingenious attempts have been made to supply a means of moderating the excess of summer temperature, or of relieving the wants which it induces. The devices for this purpose have all been based upon the natural law, that bodies undergoing a change of volume have their capacity for heat increased or diminished.

Liquefaction and evaporation have hitherto been found the most powerful means of increasing the capacity of bodies for heat; and the artificial production of these changes has constituted the chief source of artificial refrigeration, from the remotest periods up to the present time. But, though they have been found advantageous in some parts of the earth, they are far from approaching that point of usefulness which would enable us to found an industrial art of general application, and still less, to furnish to mankind the great luxury which artificial cold is capable of affording. Indeed, so imperfect have been these, and all the processes hitherto employed for producing artificial cold, abundantly and cheaply, that, at the present day, there is recognized in the want of a device that shall supply the desideratum the discovery which is most to benefit mankind.

Recent experiments, by making us accurately acquainted with the circumstances on which refrigeration depends, have given us reason to hope that processes of cooling, sufficiently effectual for all our wants, in every climate, have been discovered. Joule, in England, Regnault, in France, and, though least, the first in order of experiment, myself, have determined the mechanical equivalent of heat, and through that fact, the precise quantity of it evolved and absorbed by air, in its reduction to, and expansion from a given volume. It is generally known

to readers of periodical works in physical science, both in America and Europe, that I have applied this knowledge practically, and have invented a machine for condensing and expanding atmospheric air, which, under the maturity that repeated experiments has produced, plainly shows that sufficient cold for all practical purposes can be easily attained.

This invention is based upon the well-known physical law, that air, in expanding will absorb heat from substances which may be brought into contact with it; and it consists in a means of applying this property of air to general refrigeratory purposes, and particularly to the conversion of water into Ice.

In carrying out the object of this invention, atmospheric air is compressed, in order that it may be in a condition to expand to its former bulk; this operation is accompanied by the disengagement of heat, which it is expedient to absorb and carry off. The compressed air is then allowed to expand, in intimate contact with the substance to be cooled; and, while expanding, it absorbs the heat of such substance. The absorption of the heat, disengaged by the air during its compression, is effected by bringing in contact with it, a jet of water or other suitable liquid. As the substances which are to be cooled do not part instantly with their heat, it is expedient to allow the air to expand gradually, in order that sufficient time may be afforded for the substance to part with its heat, and for the air to absorb it.

To avoid the inconvenience that would arise from mingling the substance to be cooled with the expanding air, an intervening agent is employed, which is alternately brought into contact with vessels containing the substance to be cooled, and the expanding air, and therefore acts as a vehicle to take the heat from the substance to be cooled, and to give it out to the expanding air. The intervening agent most suitable for this purpose is a liquid which is uncongealable at the temperature to which the article to be cooled, is to be reduced.

In order to compress air a considerable amount of force must be expended: but, as the air in expanding from a compressed state will exert a considerable force, the refrigerating

apparatus is so arranged that the force which the compressed air exerts in expanding shall aid in reducing another quantity of air to the requisite degree of compression ; hence the force expended in compressing air is, to a considerable extent, recovered by its subsequent expansion.

To facilitate the attainment of a low temperature, and to maintain it with the least possible cost of power, it has been found advisable to use the same air again and again. These several points which are deemed essential to the efficient and economical working of refrigerating apparatus, acting by mechanical in contradiction to chemical means, will be found to be embraced in the arrangement of the apparatus forming the subject of the present invention.

This improved construction of refrigerating apparatus, consists, essentially, of a pump or cylinder, A, by means of which air is compressed or condensed — of a reservoir or magazine, B, into which the compressed air is forced — of a pump or engine, C. in which the compressed air from the reservoir expands and exerts its force to aid in working the condensing cylinder—of a suitable pump, d, to inject jets of water into the condensing cylinder, A, to absorb the heat disengaged by the air as it is compressed,—of a similar pump, e, to inject the uncongealable liquid into the expanding engine, C. in order that its heat may be absorbed by the expanding air,— of an insulated chamber or room, D. and of a cistern, E. in which the articles to be cooled are placed, and which also forms a reservoir for the uncongealable liquid—the latter being drawn from it to be forced into the expanding engine, whence it is returned to the cistern, after it has given out its heat to the expanding air—lastly, of a tubular refrigerating box or vessel, F. through which the expanded and cooled air passes, and in which water is cooled, prepatory to congelation.

In the accompanying Drawing, fig. 1, represents an end view of one of the forms of apparatus devised for carrying the invention into effect with the insulated room, D, the cistern, E, and the refrigerating box, F, shewn in section.

Fig. 2, represents a plan of the machine, with the refrigera-

ting box, F, removed, the insulated room, D, and the cistern, E, shewn in section.

Similar letters refer to similar parts in both figures.

The condensing pump or engine consists of a cylinder, A, which is secured to a bed frame, R, and is fitted with a piston and piston rod, P, which passes through a stuffing box in the cover, and is attached at its other end to a cross head, as in the horizontal Steam Engine.

This cylinder, A, is furnished at each extremity with two valve chests, H, H, with valves exactly similar in construction. Those on the upper side are for the purpose of admitting the air, and those on the under side for the exit of the air. The entry valves in each chest open inwards, and the exit valves open outwards. These valves are all self acting.

d, is a double acting pump by which the water of injection is forced into and supplied to the air while undergoing compression in the cylinder, A. This pump is provided with valve chests and valves of the usual construction, and worked from the Piston Rod Cross-head, through the rod, G. The suction valves are connected by the pipe, Y, with a well or any other source, whence the water is to be drawn, and the delivery valves are connected by pipes, I, and I', with the ends of the cylinder, A. These pipes terminate in plates in the cylinder heads, provided with a few holes of such a size and arrangement as to cause the water to be projected against the piston in jets, and to fall through the air in a diffused shower.

C, is the expanding cylinder, similar in its construction to the condensing cylinder, A, with the exception that it is either made of, or lined with brass.

This cylinder is mounted upon a bed frame R', and is furnished likewise at each end, with two valve chests, H', H', having suitable valves; those on the upper side being for the entry, and those on the lower side for the exit of the air. The entry valves in each valve chest open outward, and the exit valves open inwards. They are all worked mechanically. The gearing which works the entry valves is an arrangement commonly called "cut off gear," and acts in such a manner that

it shall cause each entry valve to open as the piston leaves that extremity of the cylinder at which the valve is situated, and to close at any point of the stroke at which it is desired to cut off the entrance of the compressed air.

The gearing to work the exit valves is so arranged that each valve is opened as the piston begins to move towards that end of the cylinder at which it is situated, and closes the same when the piston arrives at the end of its stroke, by which arrangement these valves are open to allow the free escape of the expanded air and uncongealable liquid throughout the whole length of the stroke of the piston.

c, is a double acting pump by means of which the uncongealable liquid is supplied to the expanding air. This pump is precisely similar in size and construction to the pump (*d*,) and is worked in a similar manner from the cross-head through the rod G'.

This pump (c) draws the uncongealable liquid through a suitable pipe, K, from the cistern, E, in the insulated room, D, and forces it into the expanding cylinder, C, through the pipes, L and L', which terminate in plates provided with holes similar to those used in the condensing cylinder.

M. M, are pipes to conduct the compressed air and water from the condensing cylinder to the reservoir, B.

N, is a pipe by which the compressed air is conducted from the reservoir, B, to the valve chests, H', of the expanding cylinder C,—O, O, are pipes to conduct the expanded air and cooled uncongealable liquid from the expanding cylinder to the cistern, E.

Q, Q,' are the connecting rods, connecting the Piston rod cross-heads with their respective cranks, S, S', fastened on to the extreme ends of the driving shaft, T.

U, is a fly-wheel placed upon the shaft, T, to regulate the motion of the two cylinders.

E, is a cistern or reservoir placed within the insulated room, D, and lined with Gutta Percha, for holding the uncongealable liquid. It is divided by suitable partitions into a number of smaller chambers. Into the division or chamber nearest the

expanding cylinder, the pipes, O, O, through which the expanded air and uncongealable liquid are conducted, terminate.

The liquid falling into the cistern circulates through openings in the partitions to the last chamber in the series, whence it is withdrawn, through the suction pipe, K, by the pump, c, which supplies the uncongealable liquid to the expanding engine. Each chamber is fitted with a moveable cover which, as well as the sides and bottom of the whole cistern, should be formed of double walls of plank, six inches apart, with the intervening space filled with saw dust, or any other insulating material, to prevent as far as possible the conduction of heat to the interior. The various pipes which convey the uncongealable liquid and the expanded air to and fro, should be made of some bad conductor of heat, as Gutta Percha, to prevent them from absorbing heat from the surrounding atmosphere, and it is also advisable to insulate the expanding cylinder, C, and its jet pump, e.

F, is a wooden refrigerating box extending nearly the whole length of the insulated room, D, and composed of two small chambers—one at each end—and an intermediate larger chamber containing a number of copper pipes, the open ends of which terminate in the partitions dividing the larger from the smaller chambers. Through these tubes the cooled air passes, and around them the water intended to be frozen is placed ; which is thereby cooled a certain number of degrees.

V, is a pipe passing from the upper part of the end of the cistern, E, into one end of the refrigerating box, F, through which the air escapes from the cistern, E, into the box, F, and which being at a low temperature is used to cool the water preparatory to being frozen.

The temperature of the expanded air, after passing through this refrigeratory, being still below that of the atmosphere, it has been deemed expedient to conduct it from the farther small chamber of the refrigerator, F, by the pipe, W, to the valve chests, H, of the condensing engine, to be recondensed into the air reservoir.

The machine thus described is intended particularly for the

congelation of water; and, as here represented, the fifteen small chambers of the series in the cistern, E, are constructed to admit and support vessels in which the water to be frozen is introduced. These water vessels are formed of thin sheet metal, which will rapidly transmit the heat of the water within them to the cold uncongealable liquid by which they are surrounded, and the sides and ends of these vessels converge downwards to permit the block of ice formed in them to be removed with greater facility.

Ice having a tendency to form itself at the surfaces of exposure to cold, the vessels just mentioned would soon be lined with a casing of it, which, as it is a bad conductor, would retard the transmission of heat from the water within, to the uncongealable liquid without, and thus the business value of the invention would be materially impaired. To counteract this injurious effect a novel and peculiar process is required, which, as it is to be made the subject of a separate patent, it is not deemed expedient to explain at present.

In manufacturing ice with this apparatus the power or prime mover, which may be animal, wind, water or steam power, is applied to turn the driving shaft, T, which, by means of the cranks, S, S', communicates through the connecting rods, Q, Q,' an alternating movement to the pistons of the condensing cylinders, A, and, C, respectively, and puts in operation the other moving parts of the apparatus.

When the piston of the condensing cylinder, A, moves from either end of the cylinder, the exit valve thereat is closed, while the corresponding entry valve is opened, by the air rushing in to fill the partial vacuum caused by this movement of the piston; and as the piston approaches the opposite end of the cylinder, the entry valve closes and the exit valve opens by the pressure to allow the condensed air to pass into the pipes, M, by which it is conveyed to the reservoir, B. Upon the return stroke of the piston these operations are reversed, and the air drawn in during the preceding stroke is compressed into the reservoir. While the air is being compresed in the cylinder, A, heat is disengaged, which is absorbed by the injection water, forced into

it, in fine jets, through the orifices in the cylinder heads by the pump, d ; and as the piston commences its return stroke this water of injection is forced out with the compressed air through the exit valves into the pipes, M, which conduct the same to the reservoir, B. In this reservoir the air and water separate ; the air passes to the expanding cylinder, C, while the water descends to the bottom of the reservoir, whence it escapes through a pipe provided for the purpose. The orifice of this escape pipe is furnished with a valve connected with a float in the reservoir ; so that, as soon as the water rises above a certain predetermined height, the valve is opened by the float to allow its escape.

The reservoir is furnished with a thermometer to indicate the temperature, and a guage to show the tension of the air within, an inspection of which is found in practice sufficient to ascertain whether the engine is performing its work in a proper manner.

As the driving shaft revolves the entry valve of the expanding cylinder, C, at that end of the cylinder from which the piston is moving, is opened by the valve gear to admit the compressed air ; and, as soon as the piston has completed a predetermined portion of its stroke, the valve gear closes the entry valve. The air in the cylinder being thus separated from that in the reservoir, expands as the piston continues moving towards the opposite end of the cylinder, and at the same time the pump, c, injects the uncongealable liquid in a shower of fine spray into the expanding air, which absorbs its heat, and thus cools it. As the piston returns in the cylinder the exit valve is opened, and the expanded air and cooled liquid are expelled by the piston, and conducted to the cistern, E, in the insulated room, D. They enter the cistern at one end of the series of chambers, and while the air escapes by the pipe, V, into the tubular refrigerator, F, the liquid passes in succession through the whole series to the last chamber, and is drawn off again by the pump, c, to be reinjected into the expanding cylinder ; and, as the latter is double acting, each stroke of the piston will expel a fresh quantity of the expanded air and cooled liquid, the latter of which, in its passage through the series of chambers, absorbs

the heat of the water, or other articles, placed therein, while the air in its passage through the tubes of the refrigerator cools the water around them.

The pistons of the expanding and condensing cylinders, being both connected with the shaft, T, the force exerted by the expanding air in the former, will tend to turn the shaft, and will thus aid in driving the condensing pump ; by which means a large amount of the power expended in the condensation of air is recovered ; while, at the same time, as the movement of the piston is gradual, the compressed air is compelled to expand gradually, and a sufficient time is given to allow the heat of the uncongealable liquid to be absorbed.

Cut-off gearing, accurately adjustable, is provided to regulate the admission of the condensed air into the expanding cylinder. Any apparatus which can be adjusted to cut off, in small fractions, from one-third to two-thirds of the stroke, will answer for this purpose ; the only object to be attained being a power of proportioning the quantities of air expanded to those compressed, in such a manner that the tension of the air in the reservoir shall remain constant.

From the foregoing description it will be understood that the action of the machine is continuous—freshly expanded portions of air being compressed and cooled, while fresh portions of the compressed air are expanded, to absorb heat from the uncongealable liquid ; and fresh portions also of the uncongealable liquid, which have absorbed the heat of the articles placed in the cistern, being drawn off by the pump and injected into the expanding air, are then returned, in a cool state, to the cistern to absorb fresh portions of heat. The uncongealable liquid acts, therefore, as a vehicle to take the heat from the articles to be cooled, and give it out to the expanding air.

The uncongealable liquid which has been employed with success in freezing water with this apparatus, is simply a solution of chloride of sodium ; but there are many liquids, either natural, or that may be artificially made, which do not congeal at the temperature at which it is desired to cool many substances, and may therefore be employed in certain cases with advantage.

This method of refrigeration has been described with special reference to the manufacture of ice; and though it is probable all refrigeratory objects will be best attained through the application of that material; yet, with slight and obvious variations in the minor details, it may be made applicable to other purposes. The expanded air might be applied directly to the cooling of the atmosphere of buildings, and of steam, and other vessels; and, thus, while promoting comfort in warm climates, tend to prevent yellow fever, and other diseases depending upon heat for their existence. The benefits of the invention in this relation will, however, appear insignificant, in the world's estimation, in comparison with other objects to which it may be applied. The cheap and abundant production of artificial cold would enable many industrial arts, requiring a low and uniform temperature, to be carried on advantageously in warm climates, or continuously in temperate regions, and thus subserve the attractive objects of economy and gain.

This invention has now been three years before the world, and the enquiry will naturally be made, why a device so simple in principle, so obvious in application, and promising valuable pecuniary results has not been brought into operation. Many causes have concurred to produce this result.

In the first place it has been found that several physical laws involved in its operation, though apparently simple and known by name to men of science, demanded, for their advantageous application, a more minute and accurate knowledge than was found to exist. Though I brought to the investigation of the subject all the thought and care I could command, and sought from every scientific source—in men and books—all the aid I deemed necessary, or could procure, yet the knowledge requisite to success was only obtained in the usual way—by repeated experiments and failures. In the course of these experiments unlooked for phenomena presented themselves, leading to the discovery of one or two natural laws, and requiring new applications of several known ones. Both classes of phenomana developed properties of matter which called for peculiar adaptations of machinery to render them fully available for the object in view.

In the construction of the machine, it was found necessary that its various parts should have a certain precise relation to each other, and that its pistons and valves should have a degree of tightness which though not required to be greater than ought to exist in the steam engine, yet, being deemed of not much importance in that machine, are commonly disregarded, and for the same reason were overlooked in the construction of this ; but, by the leakage, seriously lessened the economy of the contrivance. Differing essentially in one, at least, of its features from the steam engine, I have ~~yet~~ found it impossible to obtain the services of a mechanical engineer, who could understand or appreciate this difference ; and, in consequence, an error subversive of half the application of the principle has been repeated in every experiment. Again, it was found that the preservation of a body against the radiating influence of a high temperature called for different principles of insulation from that of a body against the absorbing action of a lower temperature. Trivial as these discoveries and errors may seem, and may be, they are sufficient to determine the utility or inutility of the invention ; and indeed, by far the greater part of the difficulty attending its development and maturity have consisted in finding out these unknown and therefore unforeseen obstacles to success.

In the second place moral causes, always equally operative with physical laws in advancing or checking the progress of human affairs, and which seem to be generally retarding attendants upon all attempts to unite science with lucre, have been brought into play to prevent its introduction into practice. Considerations paramount to pecuniary interest rendered it necessary for me, ~~(in order to punish the dishonest cupidity of other men)~~ to keep the invention for some time in abeyance. But having overcome the former, and put aside the latter set of obstacles, I am enabled to present the machine as perfect and as free for the use of mankind, as one so novel and important could be expected to be rendered by one man.

In this description of the invention, I have omitted some details essential to a perfect understanding of a principle so new, but I have mentioned enough to show that it comprises a system

of compensations which insures the highest chemical effects of the principle at an insignificant cost of mechanical power. The chemical agents being simply air and water their employment is attended with no natural expense ; and it is obvious, from the drawing, that they can be used with little artificial aid. In calculating the commercial value of the principle, the elements to be considered are the original cost of the machine, the labor of manipulation, the cost of superintendance and the quantity of power consumed.

It is apparent from the system of mechanical equivalents pervading the contrivance that the demand for power can arise from little more than that required to overcome friction ; and it is obvious that all the other charges attending the working of the machine must lessen in proportion as its magnitude is enlarged. Upon theoretical principles it may be calculated that the principle is capable of producing, within the tropics, a ton of ice for every half of a cubic foot of capacity of the expanding cylinder, with the consumption of half a horse power per day ; and, practically, it has been found that every cubic foot of capacity of the same cylinder has been able to produce a ton of ice at the cost of one horse power per day, (of twenty-four hours.)

Further particulars regarding the invention, and the price at which it will be furnished, may be obtained by application to HENRY E. ROEDER, Engineer, New-York, whom I have appointed my general agent.

JOHN GORRIE,
Of Apalachicola, Florida.

Dr. JOHN GORRIE'S ICE MACHINE.

Patented May 6th 1851

Fig. 1.

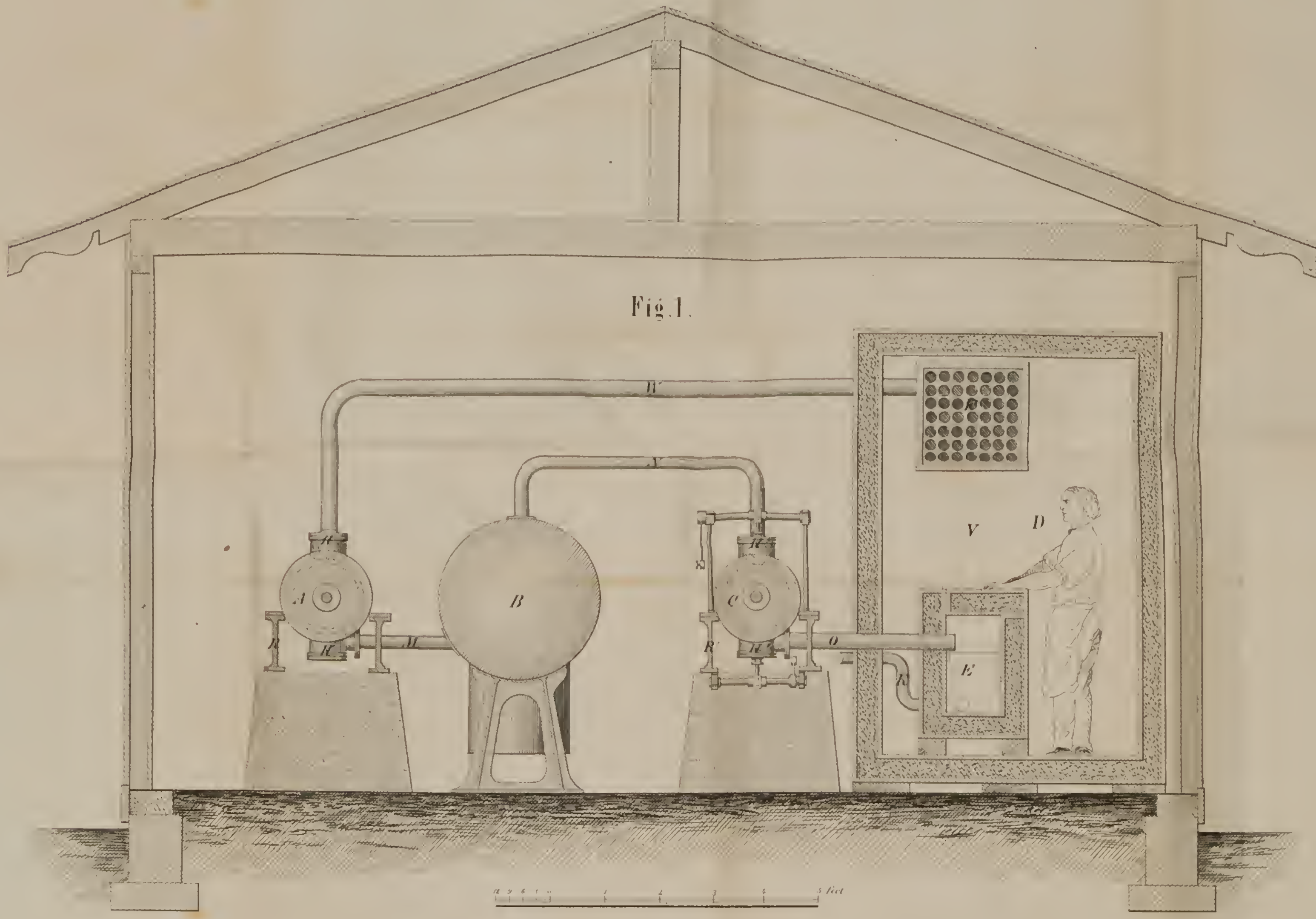
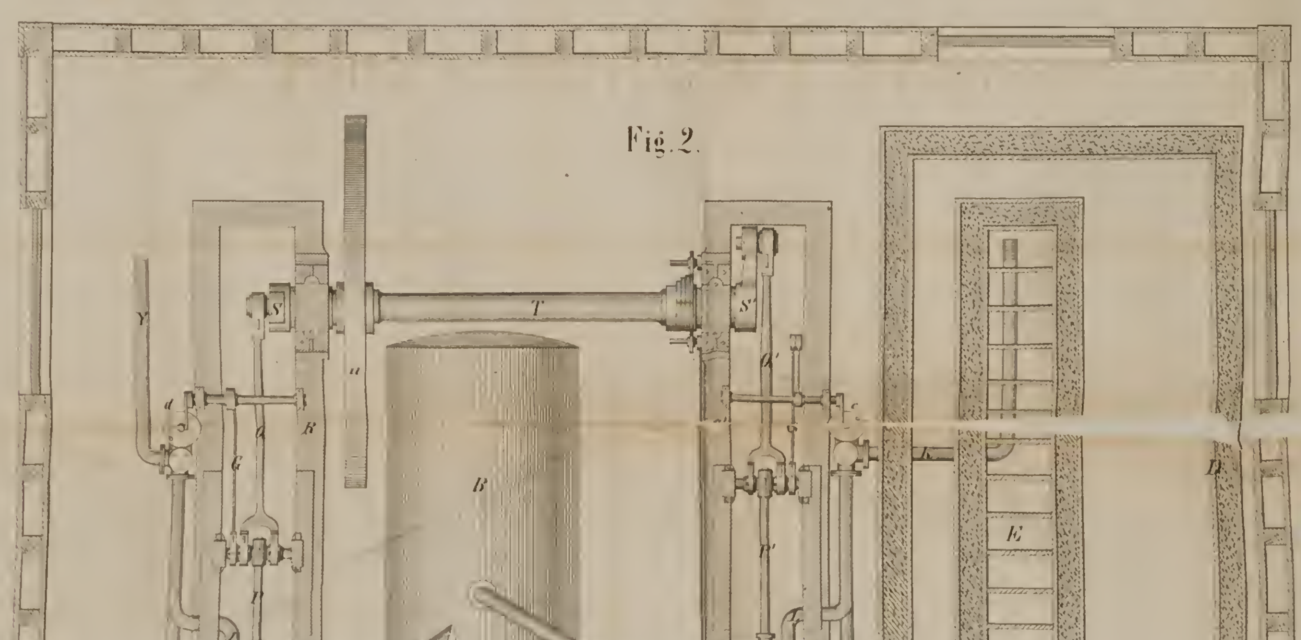


Fig. 2.



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